# COMPARATIVE EFFICACY OF TECHNICAL AND WATER-BASE FORMULATIONS OF AROSURF® MSF AGAINST *AEDES TAENIORHYNCHUS*[1]

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Technical (100% active) Arosurf® MSF (Sherex Chemical Company, Inc., P.O. Box 646, Dublin, OH 43017) and milky suspensions of this product are recommended formulations for use as a mosquito larvicide and pupicide (Anonymous 1984). The choice of formulation is dependent on the vegetative density, water surface obstructions, and the type of ground or aerial application equipment that is available.

Under typical salt-marsh conditions of Lee County, Florida, application of technical Arosurf MSF against *Aedes taeniorhynchus* (Wiedemann) is usually ineffective at recommended application of 0.2 to 0.5 gal/surface acre of water due to poor product penetration through the dense canopy (Levy et al. 1981). To prevent overdosing and to assure that an optimum number of large droplets would be dispensed for maximum vegetative penetration, Arosurf MSF can also be suspended in water for spraying at a rate of 5 to 7 gal/acre (Levy et al. 1981, 1982). Water-base Arosurf MSF is also required to spray fringe marsh areas, since standard spray systems used on roadside ditch trucks cannot be effectively modified to spray low rates of technical product at typical driving speeds (Levy et al. 1982).

Unlike most mosquito larvicides, Arosurf MSF is essentially insoluble in water, and therefore requires high sheer mixing to suspend the product in water and insure accurate application rates. Under operational conditions, high sheer mixing can be achieved by paddle agitation or by use of injection valves designed to meter precise amounts of Arosurf MSF into a high pressure stream of water (Levy et al. 1982, Burgess et al. 1985).

Although we apply Arosurf MSF mainly as a water-base formulation against immature stages of *Ae. taeniorhynchus*, some hard to reach or open marshes are sprayed by hand or helicopter with technical product (Levy et al. 1981). Recent field observations on the rates of kill of larvae sprayed with technical and water-base Arosurf MSF have shown quicker kill of larvae in areas sprayed with the water-base formulation. Water was presumed to act only as an inert carrier of Arosurf MSF once the 2 components were thoroughly mixed. Water is the classical diluent used in the application of most mosquito larvicides and therefore was not expected to contribute to the larvicidal properties of any product. Since comparative field data were minimal, laboratory bioassays were performed to determine the reliability of the preliminary field observations.

Bioassays were conducted against 1st to 4th instar larvae of *Ae. taeniorhynchus* to compare the rates of larvicidal action of technical and water-base Arosurf MSF to determine if water-base suspensions of Arosurf MSF would produce an enhanced larvicidal action when compared to the larvicidal response induced by equivalent application rates of technical product.

A series of bioassays were performed in 400 ml glass beakers containing 250 ml of 12.5% artificial seawater (Instant Ocean®) and 10 early to late, 1st to 4th instar larvae of laboratory-reared *Ae. taeniorhynchus*. Tests were replicated 3 times and monitored on a daily basis in a room maintained at ca. 27° C (ambient) and 80% RH.

Water used in the Arosurf MSF formulations had a conductivity of 370 to 410 μmhos/cm and a pH of 6.75 to 6.95. Arosurf MSF was suspended in this water at a 5.2% level by vigorous hand-shaking for 1 min. The resultant milky suspension was then pipetted into beakers containing various larval instars of *Ae. taeniorhynchus* at a total volume of 5.0 gal/acre (i.e. 0.26 gal/acre Arosurf MSF). The application rate of technical Arosurf MSF in all tests was also 0.26 gal/acre. Larvicidal efficacy of the water-base and technical Arosurf MSF formulations were compared at 24 hr intervals. Results were statistically analyzed using "z" and "t" tests.

Bioassay results were most significant against 4th instar larvae (Table 1). Data from 6 tests against 4th instar larvae showed that 47 to 97% mortality could be achieved within 24 hr posttreatment with the water-base formulation. However, mortality at this time period with technical Arosurf MSF ranged from 0 to 63%. The effect of formulation on larvicidal efficacy was further evident on day 2. In general, mortality of 4th instar larvae exposed to technical Arosurf MSF at a rate of 0.26 gal/acre was significantly more delayed than with water-base formulations containing an equivalent amount of Arosurf MSF.

Differences in larval sensitivity between water-base and technical product were not

[1] Mention of a brand name or proprietary products does not constitute a guarantee or warranty by Lee County Mosquito Control District and does not imply its approval to the exclusion of other products that may also be suitable.

Table 1. Comparative efficacy of agitated water-base and technical formulations of Arosurf® MSF against 4th instar larvae of *Aedes taeniorhynchus*[1]

| Test no. | Formulation[3] | Cumulative mean percentage mortality of larvae, pupae, and/or emerging adults at indicated posttreatment time periods (days)[2] | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Arosurf MSF + water | 63.3 | 100 | — | — | — | — |
| | Arosurf MSF | 0 | 56.7 | 76.7 | 93.3 | 100 | — |
| 2 | Arosurf MSF + water | 53.3 | 80 | 90 | 90 | 100 | — |
| | Arosurf MSF | 10 | 36.7 | 80 | 83.3 | 93.3 | 100 |
| 3 | Arosurf MSF + water | 46.7 | 100 | — | — | — | — |
| | Arosurf MSF | 6.7 | 60 | 76.7 | 83.3 | 93.3 | 100 |
| 4 | Arosurf MSF + water | 96.7 | 100 | — | — | — | — |
| | Arosurf MSF | 63.3 | 93.3 | 100 | — | — | — |
| 5 | Arosurf MSF + water | 66.7 | 100 | — | — | — | — |
| | Arosurf MSF | 40 | 66.7 | 80 | 83.3 | 86.7 | 100 |
| 6 | Arosurf MSF + water | 63.3 | 100 | — | — | — | — |
| | Arosurf MSF | 0 | 33.3 | 56.7 | Test terminated | | |

[1] Arosurf MSF Lot #4158K used in all tests.
[2] Control mortality ranged from 0–10%.
[3] Dosage of active Arosurf MSF was 0.26 gal/acre in all tests.
Water-base formulations applied at a total application rate of 5.0 gal/acre.

evident in 6 trials against 3rd instar larvae (Table 2). Kill was comparable at each posttreatment monitoring period, with a significant increase in mortality occurring on day 2. It should be noted that 3rd instar larvae of this species have been shown to be generally more sensitive to surface films of Arosurf MSF than other instars (Levy et al. 1981).

However, a trend similar to the one observed with 4th instar larvae was apparent in tests against 1st–2nd instar larvae (Table 3). Significant differences in the rates of kill of 1st–2nd instars between the technical and water-base formulations were observed on day 1 and 2; although significant mortality differences were not observed in test 2 until day 3.

In general, results of bioassays against *Ae. taeniorhynchus* confirmed preliminary field observations, and suggested that water was in some way responsible for the apparent enhance-

Table 2. Comparative efficacy of agitated water-base and technical formulations of Arosurf® MSF against 3rd instar larvae of *Aedes taeniorhynchus*[1]

| Test no. | Formulation[3] | Cumulative mean percentage mortality of larvae, pupae, and/or emerging adults at indicated posttreatment time periods (days)[2] | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 1 | Arosurf MSF + water | 50 | 96.7 | 100 | — | — |
| | Arosurf MSF | 50 | 90 | 100 | — | — |
| 2 | Arosurf MSF + water | 10 | 46.7 | 100 | — | — |
| | Arosurf MSF | 3.3 | 63.3 | 100 | — | — |
| 3 | Arosurf MSF + water | 3.3 | 43.3 | 96.7 | 100 | — |
| | Arosurf MSF | 0 | 50 | 93.3 | 93.3 | 100 |
| 4 | Arosurf MSF + water | 16.7 | 90 | 100 | — | — |
| | Arosurf MSF | 16.7 | 100 | — | — | — |
| 5 | Arosurf MSF + water | 26.7 | 60 | 96.7 | 100 | — |
| | Arosurf MSF | 26.7 | 53.3 | 96.7 | 100 | — |
| 6 | Arosurf MSF + water | 23.3 | 100 | — | — | — |
| | Arosurf MSF | 20 | 100 | — | — | — |

[1] Arosurf MSF Lot #4158K used in all tests.
[2] Control mortality ranged from 0–10%.
[3] Dosage of active Arosurf MSF was 0.26 gal/acred in all tests. Water-base formulations applied at a total application rate of 5.0 gal/acre.

Table 3. Comparative efficacy of agitated water-base and technical formulations of Arosurf® MSF against 1st–2nd instar larvae of *Aedes taeniorhynchus*[1]

| Test no. | Formulation[3] | Cumulative mean percentage mortality of larvae, pupae, and/or emerging adults at indicated posttreatment time periods (days)[2] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | Arosurf MSF + water | 3.3 | 46.7 | 73.3 | 100 | — | — | — |
| | Arosurf MSF | 0 | 13.3 | 60 | 93.3 | 100 | — | — |
| 2 | Arosurf MSF + water | 10 | 30 | 63.3 | 83.3 | 100 | — | — |
| | Arosurf MSF | 6.7 | 13.3 | 33.3 | 63.3 | 76.7 | Test terminated | |
| 3 | Arosurf MSF + water | 80 | 100 | — | — | — | — | — |
| | Arosurf MSF | 0 | 6.7 | 83.3 | 93.3 | 100 | — | — |
| 4 | Arosurf MSF + water | 10 | 70 | 83.3 | 90 | 93.3 | 100 | — |
| | Arosurf MSF | 0 | 10 | 23.3 | 56.7 | 60 | 86.7 | 100 |

[1] Arosurf MSF Lot #4158K used in all tests.
[2] Control mortality ranged from 0–10%.
[3] Dosage of active Arosurf MSF was 0.26 gal/acre in all tests. Water-base formulations applied at a total application rate of 5.0 gal/acre.

ment of the larvicidal surface-active properties of Arosurf MSF against *Ae. taeniorhynchus*. To account for this phenomenon, we focused on a fundamental property of surfactants such as Arosurf MSF, called micelle formation (Fendler 1982). This is the property that surface-active solutes, such as Arosurf MSF, have of forming colloidal-sized clusters in aqueous solution. Micelle formation is a well documented and important phenomena not only because a number of important interfacial phenomena, such as detergency and solubilization, depend on the existence of micelles in solution, but because it affects other interfacial phenomena, such as surface or interfacial tension reduction that do not directly involve micelles, but which have been shown to contribute to the larvicidal and pupicidal efficacy of surfactants such as Arosurf MSF.

Based on this information, we hypothesize that the critical micelle concentration (Fendler 1982) of this water-surfactant system is the important parameter in the explanation of the enhanced larvicidal action of water-based Arosurf MSF against *Ae. taeniorhynchus*. Among the factors known to markedly affect the critical micelle concentration in aqueous solution are, the structure of the surfactant, the presence of added electrolytes in solution, the presence in the solution of various organic additives, and the temperature of the solution. In considering if these factors affect the larvicidal properties of the solution, we will take into account operational variables such as formulation and habitat water quality and temperature, concentration of Arosurf MSF in the suspension, effect of by-products present in Arosurf MSF as a result of the manufacturing process, type and duration of agitation used in the suspending process, and effect of formulation on wetting and surface tension reduction. These factors, in conjunction with morphological differences in the larval siphon, will be evaluated in an attempt to determine the relationship between micelle formation and the larvicidal enhancement of Arosurf MSF.

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